NATIONAL BUREAU OF STANDARDS REPORT

9053

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1965

By
Photometry and Colorimetry Section
Metrology Division
Institute for Basic Standards

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT

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NBS REPORT

9053

Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report to

Ship Aeronautics Division
and
Meteorological Management Division
Bureau of Naval Weapons
Department of the Navy

and to

Federal Aviation Agency

For the Period
October 1 to December 31, 1965

By
Photometry and Colorimetry Section
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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
October 1 to December 31, 1965

I. REPORTS ISSUED

Report No.	Title
8940	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period April 1 to June 30, 1965
9025	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1965
21P-33/63 Supp.	Life Tests of Twelve Type S-471 Flashtubes Manufactured by Kemlite Laboratories
212.11P-50/65	Photometric Measurements of Ten Type PAR-64 Factory-Alined Iodine-Cycle Lamps for a Visual Approach Slope Indicator
212.11P-102/65	Temperature Measurements of an L-845 Light with a 300-Watt Lamp Installed in a Compact Base
212.11P-9/66	Output Characteristics of Five Types of Series/ Series Transformers Using Series Lamps and Multiple Lamps as Loads
212.11P-28/66	Photometric Tests of a Semiflush-Mount Pancake Light Manufactured by Crouse-Hinds Company
Memorandum Report	Synchronization of a Pair of Runway Identification Lights
Memorandum Report	Drainage of Inset Lights.

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter.

There was no activity on this task during this period. The air compressor failed during the quarter. The installation is not in operating condition and cannot be used for demonstrations until repairs are made. Work on preparation of the formal report will be resumed during the next quarter.

Transmissometers.

High Pulse Rate Receiver. The high pulse rate receiver has continued to operate without malfunction. Since the receiver has been rebuilt and a second photomultiplier tube installed the stability of the 100 Percent Setting is much better than it was with the first photomultiplier tube. However, the sensitivity of the photopulse unit has decreased approximately 15% during two months. There has been no measurable change in the sensitivity of the conventional photopulse unit in the comparison transmissometer.

250-Foot Baseline Transmissometer. The collection of data at Arcata was terminated on November 1. The photopanel equipment was returned to NAFEC at Atlantic City. One transmissometer set was shipped to the John F. Kennedy International Airport and the other transmissometer set and a set of towers were shipped to the Los Angeles International Airport. The work on this task was described in the Progress Report for July to September, 1965.

Field Tests of the Hoffman Backscatter Fog Detector Sets.

The initial field tests of the Hoffman backscatter fog detector sets have been completed. The equipment has been shipped to the Air Force Cambridge Research Laboratory. The work on this task has been described in the two previous Progress Reports.

Shipboard Visibility Meter.

The preliminary design study of the shipboard visibility meter has continued. Results of this study indicate the following:

a) Practical techniques exist to permit equal-weight averaging over 20 to 30 measuring pulses using modestly priced commercial operational amplifiers. One storage element was bench-tested.

b) Commercially available linear-to-logarithmic elements are available that promise to accomplish the desired linear-to-logarithmic conversion of the output. Actual trial of such a device will be undertaken soon.

c) The detection of the peak amplitude of the light flashes appears likely to present a substantial problem. Much of the effort is expected to be spent on this problem.

d) If all the above-mentioned elements function as expected, they may be fairly easily arranged to compensate for lamp output variations on an averaging basis, or, with more difficulty, on a pulse-to-pulse basis. A number of possible system configurations have been considered including

   1) Measurement of light output on alternate flashes and use of average for sensitivity correction.

   2) Same except use of every 3rd or 4th flash for standardization.

   3) Use of two photocell systems to obtain true ratio for each flash.

Fog Variability Studies.

During the past fog season transmittance data were recorded by the four transmissometers at the visibility test site. A limited amount of this data has now been tabulated and analyzed. The data included in this limited analysis did not indicate the marked systematic difference between indications of transmissometers T-F and T-S which had been noted in the data for previous years. A more thorough study will be made to determine if the limited conditions included in the newly analyzed data were less representative of general conditions or if the more stable foundations and the more careful maintenance procedures for the transmissometer might have eliminated some systematic instrumental errors. This data analysis will be emphasized during the next quarter.

Visibility Thresholds.

Visual range observations over the 1000-foot range in daylight were made on several occasions for comparison with transmittances obtained from the transmissometer readings during low visibility conditions. These observations included the determination of the visual range of the small targets located at different heights beside the larger targets. Seldom were there appreciable differences in visual range as a function of elevation of the small targets. There was a tendency for the highest targets to be recognized before the lower targets. Analysis of this new data was started and will be continued during the next quarter.

Frequency of Variable Fog Conditions.

The need for knowledge of the number of hours and the frequency of occurrence of the very variable fog conditions at Arcata Airport has arisen on several occasions. To estimate more accurately the frequency of these conditions, the weather observations of the Federal Aviation Agency for the year of 1964 were reviewed and the periods indicating erratic changeable visibility conditions were tabulated. The total was 305 hours occurring on 101 different days. An estimate is that at least one-third of this time would be of highly variable conditions in which the transmissometer tends to "paint" the record. These conditions occur throughout the year but occur more frequently during the fog season from July through October and last for longer periods at that time.

III. AIRFIELD LIGHTING AND MARKING

Stub Approach Beacon.

The draft of the report of tests of the stub approach beacon has been completed. The stub approach beacon can be a practical and useful visual aid for installing on approaches to runways where it is not practical to install high intensity approach lights or a complete approach-beacon system. The stub approach beacon was considered a useful supplement to the visual approach slope indicators (VASI). The stub approach beacon should be located on the extended centerline of the runway within 1000 feet of the threshold, preferably 500 feet ahead of the runway threshold. It may be installed in a pit with only the lamps above the surface of the ground. For an installation in a pit or manhole, a simple shield can be installed to prevent interference with electronic signals such as the ILS localizer signal. The optimum flash rate was 60 flashes per minute with an effective intensity between 25,000 and 50,000 candelas at the elevation of maximum intensity and a flash duration of approximately three-fourths of a second. This flash characteristic may be obtained with five steady burning lamps mounted on a turntable which rotates at 12 revolutions per minute. The lamps should have a beamspread of 40 to 60 degrees horizontally and 20 degrees vertically. A two-or three-step intensity control is required to make the beacon suitable for use in both day and nighttime conditions.

PAR-Type Lamps for MC-2 Type Prismatic Semiflush-Mount Runway Lights.

The investigation continued into the performance of the PAR-type lamps used in the MC-2 prismatic semiflush-mount runway lights. The following information is included as an introduction to the problem:

(1) A PAR-56 lamp has a reflector window 6 inches in diameter, with a total window area of about 28 square inches.

(2) The MC-2 type light (1/2 inch projection) used in the test has two exit windows with an area of 1-3/4 square inches each, or about 6% of the window area of the lamp used (for each window).

(3) The reflector area that mirrors the light to the prism (of a unidirectional unit) has a "dimple" (which locates the position of the third lead wire when used). This dimple tends to degrade the critical area of the reflector that contributes to the beam peak on the MC-2 light.

(4) The variables pertinent to the evaluation include:

a. Lamp filament placement.

b. Lamp filament wattage.

c. Filament color temperature.

d. Reflectance of silvered surface of lamp.

e. Type of lamp cover (clear or stippled) and its transmittance.

f. Transmittance (regular and diffuse) of prism.

g. Reflectance of silvered surface of prism.

h. Lamp blackening. This item was not important for testing with new lamps but is significant in the life-period evaluation of the lamp.

Items a-g are of particular interest in this investigation.

As a first step in the evaluating process, a "utilization factor" was computed by dividing the peak intensity of the MC-2 unit when lamped with the test lamp by the peak intensity of the test lamp alone. Some average values are given in table 1.

Table I. Utilization factor for PAR-type lamps in an MC-2 unit.

Lamp Type	Number of Lamps	Cover	Average Power (watts)	Current (amperes)	Average Light Utilization Factor (%)
PAR-56(Q) [1]	2	L.S. [2]	308	20	4.2
PAR-56	3	L.S.	307	6.6	6.3
PAR-56	5	L.S.	210	6.6	4.1
PAR-56	5	Clear	209	6.6	6.3
PAR-56 Rot. [3]					8.3
PAR-56(Q) [1]	6	Clear	206	6.6	9.8
PAR-56(Q) Rot. [3]					7.1
PAR-46	4	Clear	212	6.6	6.2

[1] With quartz iodine filament enclosure.

[2] Light stipple.

[3] The lamps of the previous line were rotated 180° keeping the seating plane horizontal.

Note that the utilization factor is higher for the lamps with clear covers than it is for lamps with stippled covers. Note also that with some lamps the utilization factor is greater than the ratio of the window area of the MC-2 light to the area of the reflector of the lamp.

Semiflush-Mount Pancake Light with Transparent Silicone-Rubber Light Capsule.

Photometric measurements were made of a bidirectional semiflush-mount pancake light manufactured by Crouse-Hinds Company. The light uses a 45-watt, 6.6-ampere quartz iodine-cycle lamp encased in a metal capsule with windows. The metal container is further encapsulated in a transparent silicone rubber enclosure which has two molded projections properly spaced and formed to act as lenses in front of the windows.

The peak intensity of one beam was 540 candelas; the peak intensity of the beam in the opposite direction was 500 candelas. Vertical beam spreads at the points of 50% of peak intensity were 3° and 4° for the two beams. Horizontal beam spreads through the beam peak were 6° and 4°, respectively. NBS Test Report 212.11P-28/66 was issued.

Runway Identification Lights.

Memorandum report "Synchronization of a Pair of Runway Identification Lights", describing the modification of a pair of these lights, was issued. A synchronizing system was designed and installed such that when the two units are energized and their rotations are out of phase, the power to the "slave" motor is interrupted briefly during a portion of each rotation, while the "master" motor continues to run without interruption at synchronous speed. The angular error between the two units is thus reduced by a small amount once during each rotation until the phase of the slave matches that of the master, and each unit then runs at synchronous speed.

Observations of the units made on an outdoor range indicate that a set of counter-rotating beacons will not be a sensitive indicator of alignment when viewed from heights which place the aircraft well above the main beams of the lights. Therefore, sufficient vertical beam spread must be provided in the lights of the system so that the main beams will extend upward to the cockpit cutoff angle. The system was relatively insensitive in indicating deviations in alignment up to about 5 degrees from the indicated path, but gave strong indications when the deviations were of the order of 10 degrees. The sensitivity is a function of the angular separation of the lights.

Runway Centerline Lights for SATS Mat.

The centerline light fixture for the SATS mat was redesigned to provide a horizontal beam width of approximately 10°. The lowest feasible vertical cut-off angle is approximately $1\frac{1}{2}$°. The fixture is being fabricated in the NBS Shops Division.

Drainage of Inset Lights.

A Memorandum Report "Drainage of Inset Lights" was issued. This report describes the modification of an inset light to provide forced drainage by the "breathing action" of this "sealed" type of unit. Two lights were modified by machining a sump in the bottom surface of the lamp chamber. A copper tube was inserted into the sump through a hole drilled through the wall of the lamp housing from the top surface of the housing at a point outside of the gasket that seals the removable cover plate to the housing. The hole angled down and inward through the housing wall into the lamp chamber at a point directly above the sump. After the tube was inserted, the drilled hole was sealed at both ends with silicone rubber. In laboratory tests, various amounts of water were put into the lamp chamber. In one test the chamber was filled with water up to the top surface of the housing. The unit was then assembled and operated at rated current. In each case, the expansion and breathing action in the chamber removed the water from the light chamber.

Temperature Measurements of L-845 Light with a 300-Watt Lamp.

NBS Test Report 212.11P-102/65 giving the results of this test has been issued. The task is completed.

Test of Wheels-Up Wave-Off-Light Transformer.

A transformer manufactured by Elastimold for use with the wheels-up wave-off lights was tested to determine the effects of prolonged operation. This transformer was intended to energize three 500-watt, 120-volt lamps which are flashed at approximately 90 flashes per minute to warn a pilot on final approach that his landing gear is not lowered. The test consisted of measuring the "cold" insulation resistance of each winding, before each operating period and the "hot" insulation resistance of each winding after operation. The test was planned to operate the transformer on normal load for increasingly long periods of 5, 10, 30, and 60 minutes, with overnight cooling following each period of operation. The transformer operated for the five and ten minute periods but failed after 17 minutes of the 30 minute test. At the start of the tests the cold insulation resistance of the secondary winding did not meet the cold insulation-resistance requirements of Specification MIL-T-23682(Weps). The insulation of the secondary winding became progressively poorer with each test period. The insulation of the primary winding withstood the five and ten minute tests but "hot" insulation resistance measurements indicated serious insulation deterioration after the ten-minute test. Tests of additional transformers may be needed to determine if this was a defective transformer at the beginning of the test.

Output Characteristics of Series/Series Transformers.

NBS Test Report 212.11P-9/66 has been issued. This report gives the results of tests of several types of 300-watt and 500-watt transformers in a series runway-lighting circuit using series lamps and multiple lamps. as loads. The tests were made to determine the most suitable transformer-lamp combination for use in VASI systems supplied from a runway-lighting circuit. The results of the tests indicate that the most suitable transformer-lamp combination for use in VASI systems supplied from a runway-lighting circuit appears to be a 500-watt transformer with a 20-ampere secondary and a 300-watt, 6.6-ampere VASI lamp. A 300-watt transformer with a 20-ampere secondary could be used with a 250-watt, or a 300-watt, 6.6-ampere lamp if the resulting reduction in intensity is acceptable. The use of 120-volt multiple lamps with a 500-watt, 6.6-ampere secondary transformer appears to be unsatisfactory because, for a reasonable luminous output, either the lamp voltage is too high or the load must be increased so much that there is too much dimming as the intensity setting is decreased. However, 120-volt lamps could be used with a 300-watt, 6.6-ampere-secondary transformer. A low intensity system could be designed using three 100-watt lamps connected in parallel. Failure of one lamp would not damage the other two.

Improved Cable-Fault Locator.

The Electronic Instrumentation Section of NBS is designing and constructing a feasibility model of an improved cable-fault locator based upon the design of the present TSM-11 Cable Test-Detecting Set. The circuitry for the new Signal Generator has been breadboarded and works well. Improvements over the old generator include greater output power, better frequency stability, and metered power amplifier. Like the old unit, it is protected from short-circuiting of the output terminals. The new Receiving Unit is still undergoing circuit development. The principle improvements over the old model are better frequency selectivity and improved performance of the indicating meter with weak signals. Present design activity for the Receiving Unit is directed toward the tuned amplifier, power supply decoupling, and low temperature operation.

Heliport Lighting and Marking.

A visit was made to the Ohio River Division of the Corps of Engineers to attend a conference on marking and lighting configurations for Army heliport landing pads. Another conference was held at NBS, Washington. A coding system for heliport beacons was developed. This system consists of a flash cycle with a period of one second. Each cycle is divided into 10 parts with a coding common to all beacons in five parts (half the cycle) and a code identifying the particular heliport in the remaining five parts. Suggested codings were as follows:

W G G W -	Y Y Y Y - or)		First heliport
W G G W -	W G G W -)		
W G G W -	Y Y Y - -		Second heliport
W G G W -	- Y Y - -		Third heliport
W G G W -	Y Y - Y -		Fourth heliport
W G G W -	Y - Y Y -		Fifth heliport
W G G W -	Y - Y - ▪		Sixth heliport
W G G W -	- Y - - -		Seventh heliport
W G G W -	Y - - Y -		Eighth heliport.

Heliport Beacon Code Demonstration Model.

A model for the testing of the beacon codes was designed, and construction was started. The unit will provide a means of studying combinations of various colors, and rate and duration of flashes, for the purpose of developing a suitable coded beacon for heliport identification.

Airport Ground Traffic Control Sign.

Due to frequent electrical problems encountered in the original traffic control signs, two of the units have been modified at the National Bureau of Standards and have been reinstalled at National Airport for evaluation. These units consist of an internally illuminated triangular housing which when rotated at its axis will display either the word GO or HOLD, and when power is off a blank side. Power for the traffic control signs is obtained from a series circuit supplied by a 15-kilowatt, 6.6-ampere regulator through 200-watt 6.6/6.6-ampere series isolating transformers.

Two systems of driving the signs were studied. In the first system four 30-watt or 45-watt, 6.6-ampere lamps are connected in series across the secondary of the specified 200-watt, 6.6-ampere transformer. Power for the motor drive and the clutch is obtained from a small 16/1 ratio step-up transformer connected in series with the lamps. This latter transformer is saturated at the higher brightness settings of the circuit. This system is advantageous in that there are saturated transformers in the series loop only when one or more motors are operating. In the second system the isolating transformer is saturated at all times and supplies four 115-volt lamps connected in parallel. A 2/1 step-up transformer is used between the load and the isolating transformer to increase the voltage applied to the load. In modifying these units the original drive system was removed and replaced with a system of the second type described above. An electric clutch is used to permit the sign to return to the blank position when power is turned off. A shunting capacitor has been added to protect the system from high voltage peaks which are characteristic of all isolating transformers operated under saturated conditions in series circuits. In order to obtain maximum starting torque from the motor, the lamps are not lighted until the sign has reached the end of its travel.

IV. CARRIER VISUAL LANDING AIDS

Carrier-Deck Floodlighting.

A study of the floodlighting of a carrier deck has been initiated. Some preliminary calculations have been made on the design of hoods for PAR 56 and PAR 64 lamps to provide adequate illumination of the deck consistent with the maximum feasible security.

"Modulated" Tri-Color Glide Slope Indicator.

Color coded glide slope indicators designating above-glide-slope, on-glide-slope, and below-glide-slope sectors by means of three colors have been used for many years and are still being used. These indicators have several deficiencies. Among these deficiencies are the following:

(1) Inadequate sensitivity in indicating displacement from the glide slope at long range and excessive sensitivity at close range.

(2) Displacement information is very limited (only high, on-course, and low). Hence, rate information is almost completely lacking. Pilots have been advised to fly in the transition zone between sectors to obtain more detailed displacement information and some rate information. This is a difficult procedure and is complicated by the ambiguity between transition zones.

(3) Transition zones between sectors of the order of 0.1° to 0.2° wide.

(4) Ambiguity between the transition from green to yellow and green to red when the on-course signal is green (unless the color of the green sector is near the blue limit of aviation green.

Deficiency (1) is inherent in all single station indicators.

Several years ago an attempt was made to overcome deficiencies (2), (3), and (4) by using two indicators side-by-side with one unit having a wider green, on-course, sector than the other. Pilots found this system difficult to interpret. Since tri-color indicators appear to be useful for certain types of operations and since a tri-color indicator might be a useful supplement to the FLOLS, consideration has been given to methods of improving this system.

One method of overcoming or alleviating deficiencies (2), (3), and (4) is modulation of the beams. With this system the pilot receives a steady green signal when he is within the on-glide slope sector. As he goes below this sector he receives alternate green and red flashes. The length of the flash cycle, that is the total time for a green and a red flash, is constant but the duration of the green flash decreases

and the duration of the red flash increases linearly with the angular deviation from the on-course sector until at a selected angular deviation a steady red signal is received. Similarly when the pilot is above the on-course sector, alternate green and yellow flashes are seen.

A stock three-color glide slope indicator has been purchased from the Westinghouse Electric Company and has been modified to produce the desired signals. This unit is intended for use in testing the feasibility of this method of coding. It is not intended as a prototype. Since the optimum flash characteristics are not known, the flash frequency has been made adjustable over a range of 2 to 500 cycles per minute. The width of the flash-coded transition zones can be changed by changing the filters in the unit and readjusting the modulating mechanism. With the filters presently installed the on-course sector is 0.2° high and the flash-coded transition sectors are 1.0° high.

The unit will be ready for demonstration and flight observation next quarter.

Portable Photoelectric Photometer for Measuring Output of Carrier-Deck Lights.

The design of the photometer has been modified so that the photometer can be used to check the condition of several additional types of carrier-deck lights. Construction of the photometer has continued.

V. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Specifications.

Review of Military specifications and drawings has continued. Two specification review conferences were held at the National Bureau of Standards (Washington).

Review of Proposed Manual.

A proposed Airport Lighting Circuit Manual, which was prepared by Elastic Stop Nut Corporation, was reviewed and comments were forwarded.

VI. MISCELLANEOUS

U. S. Coast Guard. Humboldt County has made an agreement with the U. S. Coast Guard for establishing an air-rescue unit at the Arcata Airport. The date for arrival of the Coast Guard unit has not been announced.


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